# Food safety risk assessment of bovine heads processing plant

## Part 2: Microbiological risk of heat treated meat products made with finished products from company X

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| Created by: | Office for Risk Assessment & Research (BuRO) |
| Applicant: | Director Enforcement |

## Motivation

The NVWA has detected violations with regard to food safety legislation at company X. Company X's main activity is the boning of beef and veal heads for the production of head meat. This head meat is then used for the production of raw finished products, whether or not ground (e.g. minced meat, beef cheeks), intended as raw material for food or pet food. The finished products of company X are actually semi-finished products, namely raw materials intended to be further processed by other companies (food, pet food). For the production of minced meat, so-called 'slaughter by-products' (offal and trimmings) are also used. Conditions have been imposed on the activities of company X with regard to the production of semi-finished products intended for human consumption. The finished products of company X may only be delivered to food businesses approved for the production of meat products (Approved food establishments: Meat products - Processing plant). Also, a heating step (at least pasteurisation) is required in the processing of meat products with raw material from company X, which adequately reduces the microbiological risk of this high-risk raw material. The raw material may also be supplied to companies approved for the production of (raw) pet food.

The NVWA has found violations at company X on various points that may have consequences for the microbial safety of the finished products produced by company X. Based on the available information, this concerns at least:

- Suspicion of use of parts of the beef not intended for human consumption in minced meat intended and used for human consumption (category 1, 2 and 3 material), including:
  - use of spoiled raw materials (category 2 material)
  - use of contaminated raw materials (category 3 material or category 2 material)
  - use of meat that may have been contaminated with brain material (category 1 material)
- Insufficient hygiene during the manufacturing process, storage at abuse refrigeration temperature
- Adjustment of unfavourable microbial laboratory results
- Placing on the market of batches of minced meat and fresh meat that did not meet the required legal standards (microbiological criteria) without informing customers
- Delivery of minced meat to companies without approval

The violations of food safety legislation identified by the NVWA may pose a risk to human health due to the presence of microbiological hazards. This concerns prions and products with excessive microbial contamination. A previously issued advice assessed the risk of prions (contamination with category 1 material). The question addressed here is what the risk is to food safety of the potentially excessive microbial contamination of the fresh meat and minced meat produced by company X, after it has been processed in an establishment approved for that purpose (Approved food establishments: Meat products - Processing plant) and where a pasteurisation step is applied in the processing process.

# Question

Is there a risk to microbiological food safety (excluding prions) if the minced meat and fresh meat produced by company X – given the observed violations of food law by company X – is processed in establishments approved for this purpose and which apply a pasteurisation process to these raw materials?

# Approach

## Methodology

As described in the microbiological hazard risk assessment methodology (BuRO, 2022), this risk assessment follows the four steps of a risk assessment (hazard identification, hazard characterisation, exposure assessment and risk characterisation) to determine whether an industrially applied heating process can ensure the safety of meat products manufactured with raw material with unknown microbial status. It only addresses the question of whether the situation in company X increased the probability of illness due to consumption of the meat products produced.

This risk assessment is carried out to support the supervision of the NVWA in the context of a food safety incident. The available information provides a picture of the situation but does not include all the details necessary to carry out a thorough risk assessment. Also, given the circumstances, there was no time for that. The situation has been examined in broad outline, and scenarios have been used to identify the risks as accurately as possible.

For this risk assessment, existing BuRO risk assessments and information on websites of public authorities in the Netherlands and abroad have been used as much as possible. In addition, simple search strategies in Scopus have been used to search for additional data on the growth of microorganisms in meat (beef) and the formation and heat stability of their metabolites (toxins, biogenic amines).

This risk assessment was not subject to peer review due to the short timelines.

## Scope

This risk assessment is limited to the situation of company X. It concerns raw meat produced after boning of beef and veal heads and fresh meat and minced meat produced from these and placed on the market. In addition to the beef heads, other raw materials (organs and such) have been used for the production of minced meat. Deviations have been found in the manufacturing process that have an impact on the microbiological safety of the raw materials produced (minced meat, fresh meat). This may have an impact on the microbiological safety of the finished products produced by company X.

Raw beef is always associated a microbiological risk. This is inherent to this foodstuff (EFSA BIOHAZ Panel, 2013; BuRO, 2024a). The risk assessment therefore focuses only on the additional risk that has arisen.

Customers of company X are diverse (including food establishments with a meat products approval, producers of pet food (approved establishments)), but also traders (food establishments without approval). The NVWA has taken measures to remove various high-risk product flows from the market. This risk assessment therefore does not focus on finished products from company X that have been supplied to customers without a meat products approval (traders). This risk assessment also does not focus on raw material intended for food businesses with an approval for the production of (raw) pet food. Raw pet food is considered a high-risk product in general (FDA, 2018; FSA, 2026). Consumers are informed about this on the packaging of raw pet food – but also in general (Dierenarts.nl, n.d.) (Reg. (EU) 142/2011)[1].

This risk assessment concerns only fresh meat and minced meat intended for manufacturing of a heat treated meat product in an approved food establishment. Only the microbiological risk is

[1] Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive.

considered. Not considered in this assessment is the fact that the use of category 1, 2 or 3 material is not allowed for the production of food.

This risk assessment relates to the situation at company X following a criminal investigation by the Intelligence and Investigation Service (IOD) of the NVWA. During the investigation, new information is becoming available over time. This risk assessment was based on the information known to BuRO dated June 5, 2026.

## Hazard identification

For the identification of microbiological hazards, it is important to know which raw materials company X has used and which finished products have been produced with them.

Raw materials used by company X are mainly beef and veal heads. For the production of minced meat 'slaughter by-products' (offal and trimmings), such as oesophagus, larynx, lungs, stomachs, kidneys, diaphragm, etc., were also used. The suspicion is that spoiled (and partly touched up for use), contaminated or insufficiently chilled raw materials have been used as well as parts not intended for human consumption. Finished products that company X produces are fresh meat (e.g. beef cheeks) and minced meat. Most of the finished products of company X are frozen.

Microbiological hazards consist of bacteria, viruses, yeasts, fungi, algae, parasites and microscopic parasitic helminths (and their toxins and metabolites). Algae are not associated with meat and from a previous risk assessment of the Dutch red meat supply chain carried out by BuRO, helminths have not been identified as a hazard from beef. All other types of microorganisms can be associated with beef.

The situation that is assessed here is the additional risk that has arisen from the manufacturing processes applied by company X. This additional risk arises partly from the use of contaminated raw material and from spoiled raw material. Use of contaminated (possibly also fecally contaminated) raw material may lead to the introduction of microorganisms other than those normally associated with beef. The assumption is that these are largely microorganisms that may normally also occur on beef (carcasses), because the contamination (mainly) originates from the processing and slaughterhouse environment. Pathogenic microorganisms may also be introduced via manure (urine, faeces) from pests (mice, rats). However, there is no evidence of pest infestation in company X, so this route is excluded for this risk assessment.

In the situation of spoilage, increased storage periods and storage at abuse temperature, only microorganisms that can multiply on meat play a role. Viruses and parasites need a living host to multiply. Viruses and parasites therefore do not contribute to the additional risk in the situation of spoilage and incorrect storage (time, temperature).

Hazards considered relevant for the topic of this risk assessment, i.e. those that could add to normal risk, are:

- spoilage micro-organisms: various bacteria including biogenic amine-forming bacteria and mycotoxin-producing fungi;
- bacterial pathogens that may be present on beef: *Bacillus cereus*, *Campylobacter* spp., *Clostridium botulinum*, *Clostridium perfringens*, *L. monocytogenes*, *Salmonella*, *Staphylococcus aureus*, STEC and *Yersinia* spp. (BuRO, 2024a).

## Hazard characterisation and exposure assessment

The starting point is that finished products from company X undergo an industrial heating process at establishments approved for this purpose (Approved food establishments: Meat products - Processing plant). The additional risk arises if this heating process is not sufficient to control the additional hazards in the meat of company X. This is the case if the concentrations of the different types of microorganisms are too high to be sufficiently reduced, or if heat stable metabolites or spores have been formed by the microorganisms.

The hazard characterisation and exposure assessment firstly addresses the general food safety situation created by the actions of company X. Subsequently, the impact this may have caused on the microbiological safety of the finished products produced by company X (minced meat, fresh meat) is considered, taking into account the characteristics of the identified hazards with regard to

growth and the production of heat stable metabolites. Finally, an assessment was made of the effect of the heating step conducted by the customers of company X (Approved food establishments: Meat products - Processing plant) on the finished products of company X.

### Microbiological quality of meat from company X

It is known that company X used spoiled and (strongly) contaminated raw materials as raw materials for the production of minced meat. These spoiled and contaminated raw materials are unsafe for human consumption and should have been downgraded to animal by-product (see Annex). These raw materials were sorted as according to company X: 'still fit for human consumption' and 'pet food'. These raw materials (may have) contain(ed) (too) high concentrations of microorganisms (spoilage, pathogenic) (scenario spoilage, scenario contamination, see Figure 1).

It is known that category 3 material intended for pet food was received by company X that did not meet the prescribed temperature of maximum 7°C (Regulation (EU) No 142/2011)[2] and that probably excessively warm raw materials (still warm from slaughter) were received for processing in pet food. It is not known whether such raw materials intended for pet food by company X have also been used for the production of minced meat intended for human consumption. BuRO does not

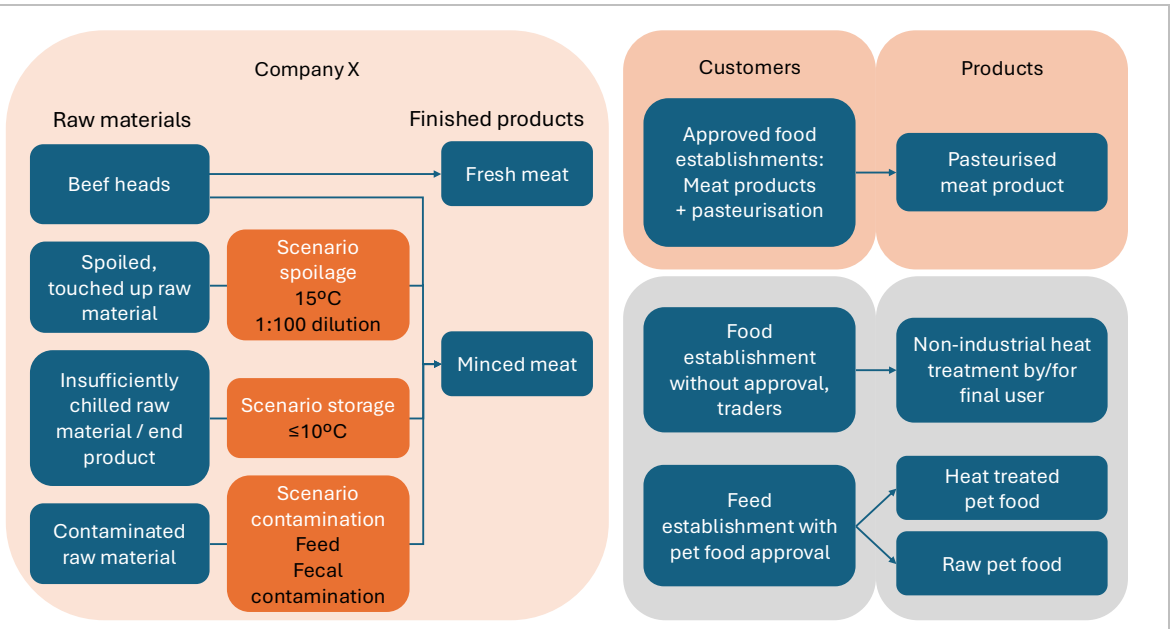


**Figure 1** Schematic overview in broad outline of the product flows within this case and the scenarios used for this risk assessment. The raw materials of company X are beef and veal heads and 'slaughter by-products' (offal, trimmings). The finished products of company X (fresh meat and minced meat) are intended as raw materials for the production of heat treated meat products (food) or for pet food. In addition, products have been supplied to mass caterers/final consumers via, among others, traders (food establishments without approval). As part of this risk assessment, the product and process flows are shown in the orange-tinted background blocks in the scheme. For the different situations where additional hazards may have arisen (increased number of micro-organisms and their metabolites) at company X, scenarios have been developed that will be discussed in the text.

[2] Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive

have any information to show that this was the case. BuRO now assumes that such product flows have actually been supplied to pet food producing establishments by company X.

It is known that raw materials and finished products have been received or stored at too high (abuse) temperatures. The deviations observed by NVWA are not much higher than +3°C. Therefore, this concerns temperatures <10°C (scenario storage).

It is known that fraud has been committed with the legally required microbiological examination (sampling, laboratory results) of the produced minced meat.

All of this implies that the minced meat and fresh meat manufactured by company X did not always meet one or more of the standards laid down in Regulation (EC) No 2023/2005 (Table 1). These concern excessive concentrations of the aerobic colony count and *E. coli* at the end of the manufacturing process (process hygiene criterion) or *Salmonella* (food safety criterion) in the finished product of company X. Exceedance of process hygiene criteria limits based on non-pathogenic microorganisms does not necessarily result in a product injurious to health. However, it does give rise to improvements in production hygiene. In case of very high exceedances, there may be circumstances that may have led to a product injurious to health. As a result of the fraud committed, it is not clear to what extent such situations have occurred, but it is known that they have occurred (*Salmonella* demonstrated in finished product of company X).

It is likely that in the raw materials that were spoiled, and which – after 'touching up' / salvaging – were used in minced meat, growth of pathogenic microorganisms could have occurred. It is not known what the conditions (time, temperature) were that led to the spoilage of the raw materials or finished products. Given that the observed temperatures for chilled products with a non-satisfactory storage temperature were <10°C, a worst-case scenario of storage at 15°C was used for the purposes of this risk assessment (scenario spoilage).

The assumption is that the batches of spoiled and contaminated raw materials and batches of raw materials that did not meet the temperature specifications were divided between batches of raw materials that were suitable as raw material for minced meat for human consumption. In other

**Table 1** Overview of legal standards for minced meat (Reg. (EC) No 2073/2005).

| Food category | Micro-organism | Sampling plan [1] | | Limits | | Stage where the criterion applies |
|---|---|---|---|---|---|---|
| | | n | c | m | M | |
| **Food safety criterion** | | | | | | |
| **1.6 Minced meat and meat preparations made from other species than poultry intended to be eaten cooked** | *Salmonella* | 5 | 0 | Not detected in 10 g [2] | | Products placed on the market during their shelf-life |
| **Process hygiene criterion** | | | | | | |
| **2.1.6 Minced meat** | Aerobic count [3] | 5 | 2 | $5\times10^5$ CFU/g [4] | $5\times10^6$ CFU/g | End of the manufacturing process |
| | *E. coli* [3] | 5 | 2 | 50 CFU/g | 500 CFU/g | End of the manufacturing process |

[1] n = number of units comprising the sample; c = number of sample units giving values between m and M. For point 1.6 m=M
[2] unsatisfactory, if the bacterium is present in one or more sub-sample(s)
[3] *E. coli* and aerobic colony count in minced meat:
- satisfactory, if all observed values are less than or equal to m;
- acceptable, if a maximum of c/n values are between m and M, and the rest of the values observed are less than or equal to m;
- unsatisfactory, if one or more of the values observed are greater than M or more than c/n values are between m and M.
[4] CFU = colony-forming units, a measure of the number of living microorganisms

words, the unsafe raw materials have been diluted. It is not known what ratio was minimally used (scenario spoilage, scenario contamination).

The finished products of company X are partially frozen. Freezing is generally considered as a treatment that has no relevant reducing effect on the number of bacteria present (concentration). However, freezing does have a killing effect on parasites.

### Characteristics of the relevant microorganisms

#### Spoilage organisms

Spoilage-causing microorganisms (bacteria, fungi, yeasts) make food inedible (odour, taste, texture), but in most cases do not cause disease in humans. A spoiled food is unfit for human consumption, but not injurious to health. Exceptions are spoilage-causing bacteria that can form biogenic amines, and fungi that form mycotoxins.

*Spoilage-causing microorganisms*

Observable spoilage occurs at high concentrations of bacteria or yeasts in the food or due to mould formation, the latter is discussed below. Bacteria and yeasts can grow to high numbers. This occurs faster at higher temperatures (e.g. room temperature, in hours) but can also take place at refrigerating temperature (days). Food is considered unfit for human consumption if the concentration of bacteria (aerobic colony count) exceeds 7-8 log CFU/g (FSAI, 2020). This number is used as a standard for, among other things, meat to be consumed raw and for MAP and vacuum-packed meat (MAP: modified atmosphere packaging). In reality, the colony counts of spoiled products may be even higher (9 log CFU/g).

Bacteria and yeasts are vegetative cells that are killed by the normal pasteurisation process (a process equivalent to 15 s at 72°C).

*Bacteria that form biogenic amines*

The microbial breakdown of animal proteins by decarboxylation processes (breakdown of amino acids) produces biogenic amines, which can be toxic in high concentrations. Biogenic amines are produced by a wide group of bacteria and yeasts, with the concentration of amines increasing as the hygienic quality of a product decreases. The presence of toxic levels of biogenic amines is correlated with a high concentration (>7 log CFU/g) of decarboxylating microorganisms (Pérez et al., 2026).

High concentrations of biogenic amines are found – in addition to fish (products) – mainly in fermented products, but biogenic amines can also be formed in fresh meat (Pérez et al., 2026). Meat (products) are a good source for the formation of biogenic amines due to their high protein content. Fresh meat normally has low concentrations of biogenic amines. However, if stored for too long or at a too high a temperature  or if poor quality (unhygienic) raw materials are used, large quantities of biogenic amines can be formed (Pérez et al., 2026).

Biogenic amines are heat stable, thus, they are not inactivated during the heating processes normally applied in the food industry, including cooking (Gardini et al., 2016; Liu et al., 2024; Pérez et al., 2026).

Under normal circumstances, minced meat or fresh meat are not associated with a risk to biogenic amines. It cannot be ruled out that in the situation of company X where spoiled meat was used, the formation of biogenic amines could have taken place.

*Fungi*

Mould was present in the production and processing environment. Due to the observed failures in process hygiene, it is possible that fungi have ended up on the raw materials or finished products of company X. Fungi can form toxins (mycotoxins), these toxins usually do not pose an acute health risk but cause long-term negative health effects after longer times of exposure. Mycotoxins are quite heat-stable and are not inactivated by a pasteurisation process (Bullerman & Bianchini, 2007).

Mycotoxins (including aflatoxin B1 and B3, ochratoxin A (OTA)) have been detected in dried meat and salted meat products (ham, sausage) (BuRO, 2024b). These are products that can be stored for a longer period of time, whether or not at refrigerating temperature. The finished products of company X have a much shorter shelf life, must be kept refrigerated (at least 7°C or lower) or

have been frozen. Therefore, it does not seem likely that mouldy finished products have been supplied by company X.

### Pathogenic microorganisms from meat

An overview of growth characteristics of pathogens relevant to this case is presented in Table 2. The minimum growth temperature included in this table is the value estimated or observed in scientific research conducted under ideal conditions. This value may be different for minced beef. Therefore, for each pathogen additional relevant information on growth in raw meat (beef) has been provided in the text.

**Table 2** Overview of relevant characteristics of the identified pathogens that may be present on beef and are relevant to this case.

| Microorganism | Tmin (°C) [a] | $O_2$ [b] | # minimum [c] | Spores | Toxin/metabolites |
|---|---|---|---|---|---|
| ***B. cereus*** | 4 | -/+ | >$10^5$ CFU/g | yes | heat-stable |
| ***Campylobacter* spp.** | 30 | ± | >500 cells | no | |
| ***C. botulinum*** | | | | | |
| **proteolytic: A,B,F** | 10 | - | Growth needed | yes | heat-labile |
| **non-proteolytic: B,E,F** | 2,5 | - | Growth needed | yes | heat-labile |
| ***C. perfringens*** | 4-10 | -/± | >$10^6$ CFU/g | yes | |
| ***L. monocytogenes*** | -2.8 | -/+ | $10^3$-$10^4$ cells | no | |
| ***Salmonella*** | 4.3 | -/+ | >1 cells | no | |
| ***S. aureus*** | 7 (growth)<br>10 (toxin) | -/+ | >$10^5$ CFU/g | no | heat-stable |
| **STEC** | 3.5 | -/+ | ±10-100 cells | no | |
| ***Yersinia* spp.** | -5.6 | -/+ | $10^4$-$10^8$ cells | no | |

[a] Tmin: minimum growth temperature
[b] $O_2$: Oxygen needed for growth; - : strictly anaerobic, ± : micro-aerophilic, + : strictly aerobic: -/+ : both aerobic and anaerobic growth (facultative anaerobic)
[c] minimum concentration in the food or minimum amount associated with disease or toxin formation in the food (or both in the case of *B. cereus*)

#### *Bacillus cereus*

*B. cereus* is a spore forming bacteria (heat-stable spores) and produces a heat-stable toxin (cereulide) in food. This toxin is produced during the exponential growth phase, starting at a concentration of $10^5$ cells/g (Table 2). *B. cereus* causes diarrhoea by ingestion of high numbers of *B. cereus* cells or spores in food (>$10^5$ CFU/g) or causes vomiting by a pre-formed toxin (cereulide) in food. Cereulide is extremely heat-stable.

Outbreaks of *B. cereus* food poisoning (cereulide) are mainly caused by starchy products such as rice and pasta dishes. Meat or meat products play a marginal role in food poisoning caused by *B. cereus* (BfR, 2005b). Therefore, the EFSA opinion on this pathogen does not mention meat or meat products as being relevant (EFSA, 2005). Outbreaks are mainly caused by products in which growth of *B. cereus* has occurred during insufficiently cooling down of cooked products.

*B. cereus* strains that produce cereulide only grow at temperatures of 10°C or higher, while toxin production usually only takes place from 12°C (with an optimum temperature from 20°C). There are a number of studies that focussed on outgrowth of *B. cereus* in meat (products). In naturally contaminated raw burgers, *B. cereus* grew up to log 6 CFU/g in 8 hours at 20°C (Soleimani et al., 2018). Other studies used heat treated meat, of which Agata et al. (2002) showed growth in meat (products) (24 hours at 30°C), but no toxin production. Another study showed (partial) growth in cooked minced meat at 10°C (maximum 1 log CFU/g increase in more than 1 day) (Soares et al., 2012). In another study using a heat treated meat slurry, *B. cereus* grew at 12°C (approximately 5 log CFU/g increase in 5 days) and toxin was produced after 5 days (Ellouze et al., 2021).

*B. cereus* seems to be able to grow in minced meat at a higher refrigeration abuse temperatures. In heat treated meat products, growth and toxin formation can occur at 12°C (time in days). It is

unclear whether *B. cereus* can also grow and form toxins in raw minced meat at 15°C. Growth and toxin formation at <10°C does not seem likely.

*Campylobacter spp.*

*Campylobacter* does not form spores, is micro-aerophilic and does not grow at temperatures below 30°C (Table 2).

It therefore does not seem likely that *Campylobacter* has been able to grow in the raw material or the finished products of company X in the situation of spoilage or storage at abuse refrigerating temperatures (15°C, or 10°C).

*Clostridium botulinum*

*C. botulinum* is strictly anaerobic, is a spore-forming bacterium and produces the highly toxic botulinum toxin. Botulinum toxin is not heat-stable and can be inactivated with heating. Two types of *C. botulinum* are distinguished, the proteolytic variant (grows from 10°C) and the non-proteolytic variant (grows from 2.5°C) (Table 2).

*C. botulinum* can only grow in the absence of oxygen (low redox potential). These conditions can be met in case of an insufficient heating step in canned food production. But also during spoilage, the oxygen content in a product can decrease. Botulinum toxin may also be formed when curing errors are made during the production of large raw or cooked cured meats. In principle, the conditions in minced meat are not suitable for growth of *C. botulinum* (high redox potential). However, this may be different for large quantities of fresh meat (offal, muscle meat; low redox potential) (BfR, 2005b).

There is experimental evidence that *C. botulinum* can produce toxin in vacuum-packed, chilled fresh lamb at 2°C, but this was only after 55 days of storage (Moorhead & Bell, 1999; BfR, 2005b). At 6°C, toxin was produced after 17 days, at 8-10°C after 10-11 days and at 12-15°C after 3 days. In other studies on the toxin production of *C. botulinum* in fresh beef (vacuum-packed) stored at 8°C for 50 days, no botulinum toxin was detected (i.e. <40 pg type B toxin and type E toxin per g meat) (Peck et al., 2020).

Botulinum toxin is not heat-stable. The toxin is inactivated by boiling (100°C), but at temperatures starting from 85°C it takes at least 5 minutes for the toxin to be inactivated (BfR, 2005b; RIVM, 2008). Pasteurising will, therefor, not result in inactivation of the toxin.

It seems unlikely that under normal circumstances botulinum toxin is formed in minced meat. This also applies in the case of incorrect storage or storage after the expiry date (BfR, 2005b). However, in the situation of company X, spoiled meat has been used as raw material, therefore, it cannot be entirely ruled out that this may have led to conditions in which botulinum toxin may have been formed.

*Clostridium perfringens*

*C. perfringens* is a spore-forming bacterium and grows at temperatures from 10°C and higher. Illness is associated with consumption of high concentrations of *C. perfringens* in food (>$10^5$ CFU/g) (Table 2).

Outbreaks are associated with consumption of cooked foods that are not sufficiently cooled down after cooking. Outbreaks are not associated with consumption of raw products that are not sufficiently chilled.

A study on the growth of *C. perfringens* in pea soup shows that none of the strains tested (n=10) did grow at 10°C and that only from temperatures ≥15°C growth partially occurred at a rate of up to 1 log CFU/g increase per 10 hours (de Jong et al., 2004). Also in pasteurised mince, growth did not take place until 15°C (Juneja et al., 1994). The latter study showed that temperature abuse of 6 hours at 28°C did not result in growth of *C. perfringens.*

It is likely that in the chosen worst-case scenario (spoilage caused by storage at 15°C), (slow) growth of *C. perfringens* to higher numbers could have occurred. Growth at 10°C does not appear to cause growth to significantly high cell numbers (scenario storage).

*Listeria monocytogenes*

*L. monocytogenes* does not form spores and can grow from -2.8°C (Table 2).

It is very likely that *L. monocytogenes* grows on fresh meat at low temperatures. This also applies to the chosen worst-case scenario (spoilage caused by storage at 15°C) and the more realistic scenario of spoilage by / storage at 10°C (scenario spoilage, scenario storage). At 7°C, an increase of 4.5 log in 15 days is estimated (EFSA BIOHAZ Panel et al., 2026).

*Salmonella enterica (non-typhoidal serotypes)*

*Salmonella* does not form spores and can grow from 4.3°C. Illness can be caused by ingestion of low levels of *Salmonella* in food (Table 2).

The minimum growth temperature of *Salmonella* in minced beef is higher than the minimum growth temperature observed for this pathogen under ideal conditions, namely around 10°C (Huang, 2020). From around 17°C, *Salmonella* grows faster than the natural occurring microflora present on minced meat (Huang, 2020). In the study of Borneman et al. (2009), growth of *Salmonella* in fresh minced beef was also observed at 10°C, albeit only after 2 days and very slowly (1 log CFU/g in 3.5 days). Also, Haque et al. (2023) show that *Salmonella* grows at 10°C in fresh minced meat (pork), about 2.5 log CFU/g in 8 days (up to log 6.5 CFU/g). In the study of Borneman et al. (2009) growth at 15.6°C commenced after more than 8 hours, at a rate of 2.3 log CFU/day. This is similar to another study using minced beef in which *Salmonella* grew at 16°C with an increase of about 4 log CFU/g in 2.5 days (Sabike et al., 2015). Growth of *Salmonella* is reduced by the growth of the natural microbial background flora of meat, with the aerobic colony count and *E. coli* increasing 3-5 times faster than *Salmonella* at 10°C (Haque et al., 2023). Also, at 7°C *Salmonella* grows slowly on beef, the growth rate is estimated at about 1.5 logs in 15 days (EFSA BIOHAZ Panel et al., 2026).

It is likely that in the chosen worst-case scenario (spoilage caused by storage at 15°C) growth of *Salmonella* could have occurred. In the more realistic case of spoilage (and growth during storage) at <10°C, growth is still possible, but slow.

*Staphylococcus aureus*

*S. aureus* does not form spores. This pathogen produces heat-stable toxins in food during growth. Growth can occur at lower temperatures (from 7°C) than toxin production (10°C). Toxin production occurs only when higher cell concentrations are reached in food (> $10^5$ CFU/g) (Table 2).

Meat and meat products are well able to support growth of *S. aureus,* especially in the absence of other microorganisms (background flora; for example, the naturally present bacteria, such as spoilage-causing bacteria). However, in the presence of background flora, the growth of *S. aureus* is reduced.

In minced beef, no growth of *S. aureus* was observed at a temperature of 15.6°C and below, only from 18.4°C did growth occur (after 12 hours, at a rate of 1 log CFU/15 hours) (Borneman et al., 2009). On fresh pork, *S. aureus* could grow starting from 10°C, but growth did not increase more than 1 log CFU/g (14 days). At 15°C, the increase after 4 days was approximately 4 log CFU/g (Mansur et al., 2016). Also on cooked pork (ham) stored at 10°C, the concentration of *S. aureus* did not increase by more than about 1 log CFU/g in 14 days. At 13.5°C the increase was 2 log CFU/g in approximately 16 days and at 17.7°C the maximum was reached (approximately 8.5 log CFU/g) in approximately 8 days (approximately 3 log CFU/g increase) (Castillejo-Rodríguez et al., 2002).

The toxins formed by *S. aureus* are heat stable. At pasteurisation temperatures (70-80°C), inactivation takes a long time (several hours).

Based on the chosen worst-case scenario (spoilage caused by storage at 15°C), it does not seem likely that sufficient growth and therefore toxin production by *S. aureus* could have taken place in minced meat or fresh meat.

*Shiga toxin-forming Escherichia coli (STEC)*

STEC does not form spores and can grow from 3.8°C. Intake of low amounts of STEC can already cause illness (Table 2).

In the study of Borneman et al. (2009) STEC growth in fresh minced beef was observed at 10°C, albeit only after 1 day and very slowly (1 log CFU/g in about 1.5 days). At 15.6°C growth started after 6.5 hours, at a rate of 2.2 log CFU/day. Also Haque et al. (2023) show that STEC grows at 10°C in fresh minced meat (pork), with the same characteristics as *Salmonella* (approximately 2.5

log CFU/g in 8 days (up to approximately log 6 CFU/g)). STEC can also grow on beef at 7°C, with an estimated increase of 3.6 logs in 15 days (EFSA BIOHAZ Panel et al., 2026). Growth of STEC, like *Salmonella*, is also reduced by growth of the natural background flora of meat, with the aerobic colony count and *E. coli* increasing 3-5 times faster than STEC at 10°C (Haque et al., 2023).

Based on the chosen worst-case scenario (spoilage caused by storage at 15°C), it is likely that growth of STEC could have taken place. In the more realistic case of (spoilage caused by) storage at <10°C, growth still seems possible, but slow.

*Yersinia*

*Yersinia enterocolitica* does not form spores and can grow from a temperature as low as -5.5°C.

*Y. enterocolitica* mainly occurs in pigs but sometimes can also be found in cattle. The *Y. enterocolitica* strains isolated from beef are often non-pathogenic, therefore *Y. enterocolitica* from beef is not considered a very important source of human illness (EFSA BIOHAZ Panel et al., 2026). Illness is associated with consumption pork or vegetables. It is unclear whether and how often (pathogenic) *Y. enterocolitica* occurs or beef. On pork, this pathogen can grow at 3°C and at 7°C, with an estimated increase of 9 log in 15 days (endpoint storage scenario) (EFSA BIOHAZ Panel et al., 2026).

If present, this pathogen – given its growth characteristics – may have grown under the chosen worst-case scenario (spoilage caused by storage at 15°C), this also applies to the more realistic scenario of (spoilage by) storage at <10°C.

### Heating process

The minced meat produced by company X must be used for the manufacturing of meat products in establishments approved for this purpose (Approved food establishments: Meat products) and the manufacturing process must include a heating step (pasteurisation). It is not known which criteria are applied to the heating process by the different customers of company X.

In the U.S.A, the 'Meat and Poultry Hazards and Controls Guide' provides a guideline for the heating process of meat products made from raw beef. A process that achieves a 6.5-log reduction of *Salmonella* is recommended for the manufacturing of fully cooked beef (for the production of a heat treated meat product) (USDA-FSIS, 2018).

For consumers, the USDA-FSIS has guidelines on the safe preparation of minced meat and minced poultry meat on its website. For minced meat (which is non-poultry meat, but for example beef) it is recommended that the core temperature must have reached 71.1 °C.

It is generally accepted that a pasteurisation process of 15 sec at 72°C (core temperature) is sufficient to result in a safe product.

Combining these data (safe = 6.5-log reduction of *Salmonella*; safe = core temperature 71.1°C) would imply that a pasteurisation process of 15 sec at 72°C should be sufficient to achieve a >6.5 log reduction of *Salmonella* in minced beef.

In a meta-analysis of the effect of heating on survival of different pathogens, van Asselt & Zwietering (2006) calculated the mean D-values of different pathogens on the basis of a large number of D-values (determined in different matrices) extracted from literature. The D-value is the decimal reduction time, which is the time required at a certain temperature to decimate the number of living bacteria (or spores), thus reducing it to 10% of the original number. The authors then used the calculated D-values to determine the effect of a standard pasteurisation process on pathogens (Figure 2). This analysis shows that based on these data *E. coli*, *S. aureus* and *C. perfringens* (vegetative cells) are slightly less sensitive to pasteurisation treatment than *Salmonella*. Also Figure 2 shows that spores of *B. cereus*, *C. botulinum* and *C. perfringens* are not killed by such a process. However, the data from this publication imply that, on average, the pasteurisation process does not provide an adequate reduction for many pathogens, because the starting point of pasteurisation is a reduction of at least 5 log CFU/g.

However, it is assumed that the meat processing industry (approved for the manufacture of meat products) applies HACCP-based principles to the manufacturing process. This implies that food businesses have verified that the applied heating process intended as a pasteurisation process ensures a bacterial reduction of at least 5 log, so that the heating process - under normal conditions - results in a safe product.

These HACCP-based procedures also include control of incoming raw material. This can be based on sensory evaluation (smell, sight), and on random physical checks (laboratory testing).

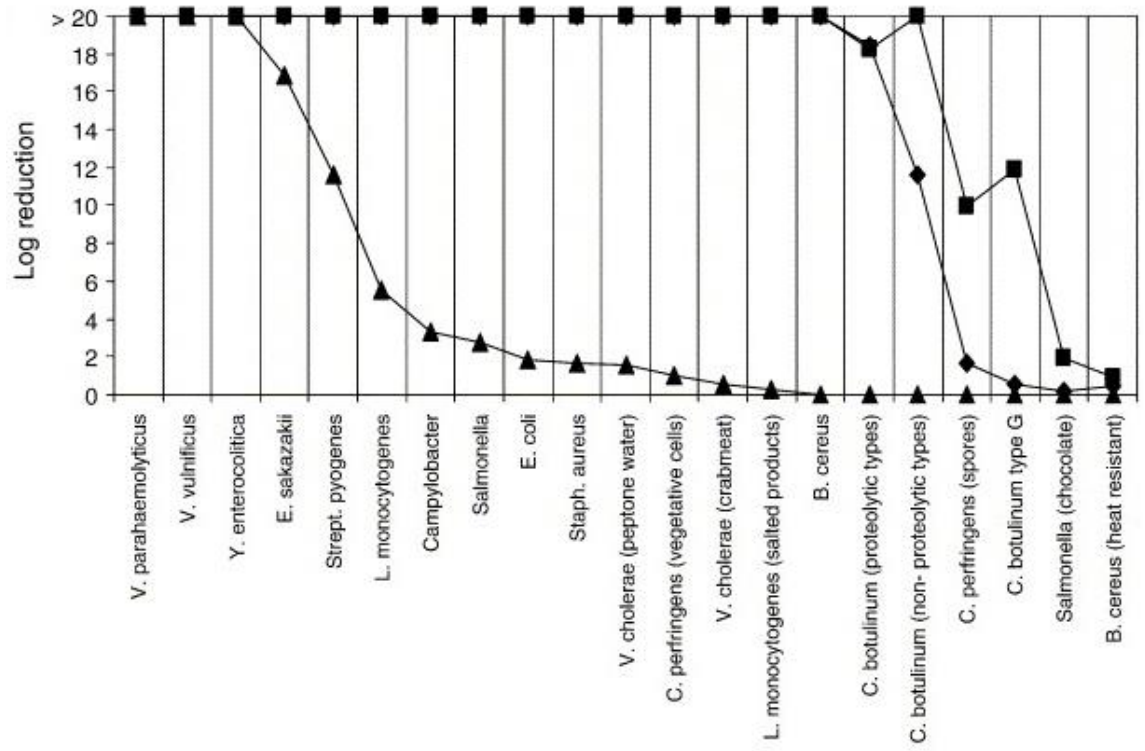


**Figure 2** Estimated log reductions of different pathogens for a pasteurisation process based on mean D-values (▲: 15 s at 72°C; the other symbols refer to sterilisation processes). The mean D-values have been estimated on the basis of a meta-analysis by van Asselt & Zwietering (2006). The figure is taken from that publication.

## Risk characterisation

- The risk factors that seem to be most important to this case at company X, are, based on the information available to BuRO, the use of (heavily) contaminated and spoiled raw materials and the storage of raw materials and finished products at abuse refrigerating temperature or for too long a time.
- Due to the use of (heavily) contaminated raw materials (meat), the microbiological contamination on this meat will be higher than normal. It is known, for example, that some batches of beef heads were contaminated with feed (visible contamination). Cattle eat silage, which is known to potentially contain *L. monocytogenes* (BuRO, 2017). Suppose that feed particles containing *L. monocytogenes* have ended up in the minced meat, this feed constitutes only a limited part of the entire batch due to mixing with the meat. Assuming that the part of feed is 0.1% in the batch and the contamination of feed would be reasonably high (assuming 6 log CFU/g), then the concentration of *L. monocytogenes* in the whole batch of minced meat would be 3 log CFU/g. This appears to be a suitable worst-case scenario for *L. monocytogenes*. For fecal pathogens it could, for example, involve 0.01% of the batch with a concentration of 7 log CFU/g, which results to the same level of contamination. A lower contamination percentage with feces was assumed here, because it is known that visible feed residues were present on contaminated raw materials and, as far is known to BuRO, there was no visible contamination with manure. If other types of contamination are concerned, the bacterial concentration is very likely to be a lot lower than that in manure.
- Storage of meat at abuse refrigeration temperature or for extended time, may result in growth of bacteria. However, spoilage already occurs at 2-7°C, especially for minced meat, this can

occur just after 2 days without the application of further conservation measures (BfR, 2005a). In any case, bacterial growth could have taken place in the spoiled raw materials. It appears that 15°C represents a fairly severe worst-case scenario in this regard, and that it is more realistic to assume storage at <10°C, also considering the temperature deviations of the raw materials and finished products measured by the NVWA (+2-3°C above the legally prescribed 2-3°C for these foodstuffs (Reg. (EC) No 853/2004)).[3]
    - It cannot be ruled out (given the situation) that biogenic amines were formed by spoilage-causing microorganisms in raw materials that were spoiled. It does not seem very likely that mould formation (and therefore production of mycotoxins) occurred in the product.
    - It does not seem very likely that growth and toxin formation in the meat has taken place due to the toxin-forming pathogenic bacteria *B. cereus* (maybe) and *S. aureus* (not likely). The same applies to *C. botulinum,* which produces highly toxic botulinum toxin. The latter is also supported by the fact that no botulism cases are known in the period 2023-2024 in the Netherlands (RIVM, 2025).
    - Various pathogens can grow (slowly) at 15°C, these are *C. perfringens* (not at 10°C), *Salmonella* and STEC (slowly at 10°C, approximately 2-3 log CFU/g increase in 4-7 days). *L. monocytogenes* and *Y. enterocolitica* (not associated with beef consumption) may grow well at low temperatures and may have reached higher concentrations. However, for *L. monocytogenes*, the legislation assumes that products stored for less than 5 days do not support growth of this pathogen. Growth (>0.5 log increase) will therefore probably only take place after storage of 5 days or longer, it is unknown, however to BuRO, for how long products (raw material, finished product) of company X were stored under refrigeration. Growth of *Campylobacter* will not have occurred.
- Suppose that in the spoiled raw material growth of pathogens has occurred (scenario spoilage), then the bacterial number could possibly have increased by 5-6 log CFU/g (assuming the scenario of 15°C). With storage at <10°C, outgrowth in the spoiled raw material is probably limited to less than 3 log CFU/g. In batches that were not spoiled, but where the temperature during storage was too high (+2 to 3°C), growth may also have taken place, but for many of the pathogens this growth will have been marginal.
- It is assumed that batches of spoiled raw materials have been mixed with batches of non-spoiled raw materials to mask the use of spoiled raw material. The dilation factor applied is not known, but it may lie somewhere between 1:100 and 1:10. Assuming a 1:100 dilution is used, the contamination is mixed through the batch, resulting in an increase of 3-4 log CFU/g for the "mixed" batch (assuming growth at 15°C; scenario spoilage). Spoilage by storage at <10°C seems however more realistic, whereby the increase in the "mixed" batch is diluted to 1 log CFU/g. With a less strong dilution (say 1:10), then in that case (assuming storage at <10°C) the increase in the "mixed" batch is 2 log CFU/g.
- This dilution factor also contributes to the risk that is associated with any of the biogenic amines that may have been formed.
- The additional risk posed by the increased concentration of pathogens in the finished product of company X is affected by the probability that a certain concentration of pathogenic bacteria causes illness in humans. For most pathogens, this probability of causing illness is only plausible due to ingestion of higher numbers of cells (B. *cereus*, *C. perfringens*, *Y. enterocolitica, L. monocytogenes*). This does not apply to *Campylobacter, Salmonella* and STEC (Table 2), which already cause illness after ingestion of a small number of cells.
- The pasteurisation process is aimed to achieve a >5 log reduction of vegetative microorganisms. It is possible that heating processes applied in the meat processing industry (Approved food establishments: Meat products) will yield an even higher reduction, based on criteria recommended by, for example, the USDA-FSIS.
    - There are no food safety criteria for *Y. enterocolitica* in the EU or the Netherlands, but the likelihood that ingestion of a small number of cells of *Y. enterocolitica* will cause illness is lower than with pathogens such as *Salmonella* and *Campylobacter* spp. For *Y. enterocolitica,* the number of cells required to likely cause illness in humans is estimated at 10,000 – 100,000 cells (BuRO, 2024a), so that for the purpose of this risk assessment it seems justifiable to use the food safety criterion for *L. monocytogenes* for this pathogen.

[3] Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin

- After pasteurisation, the finished product (a ready-to-eat foodstuff) should comply - based on food safety criteria laid down in EU and Dutch legislation - with 2 log CFU/g *L. monocytogenes* (and consequently also for *Y. enterocolitica*) (100 CFU/g; Reg. (EC) No 2073/2005[4], 5 log CFU/g for *B. cereus*, *C. perfringens* and *S. aureus* (100,000 CFU/g; Commodities Act Decree on the Preparation and Treatment of Foodstuffs (Wbbl)[5] and -1.4 log CFU/g for *Campylobacter*, *Salmonella* and STEC (not detected in 25 g; Wbbl). Without safety margins, the maximum concentration in the finished product of company X should therefore have met 7 log CFU/g for *L. monocytogenes* (and *Y. enterocolitica*), 10 log CFU/g for *B. cereus*, *C. perfringens* and *S. aureus,* and 3.6 log CFU/g for *Campylobacter*, *Salmonella* and STEC.
- Assuming the scenario of mixed spoiled meat (15°C; 3-4 log CFU/g increase), the margin is not very large for the fecal pathogens *Campylobacter*, *Salmonella* and STEC. If spoilage at 10°C is assumed, the additional risk is posed by an increase of 1-2 log CFU/g in the mixed meat. Pasteurisation then provides an adequate reduction, assuming that normally these pathogens should be absent in 25 grams of product (a concentration of -1.4 log CFU/g). Pasteurisation provides an effective reduction of the microbial load in the scenario of storage at abuse refrigerating temperature (increased temperature with +2°C to 3°C) in which the outgrowth of most pathogens will be marginal (and that of *L. monocytogenes* will not exceed 7 log CFU/g).

- Pasteurizing has little to no effect on the reduction of bacterial spores. Spores of *B. cereus*, *C. botulinum* and *C. perfringens* will survive the pasteurisation process. Since no growth of these pathogens is expected in the raw materials or finished products of company X, their numbers may only have been increased by the (heavily) contaminated raw materials. Control of these pathogens lies – just as normal – in proper storage of the heat treated meat products made from the minced meat of company X by approved companies (meat products approval).
- Additional information regarding circumstances:
  - It is known that minced meat from company X was supplied to non-approved food businesses (traders) who resold the product to, amongst others, mass caterers (see Reg. (EU) No 1169/2011 for definition)[6]. These mass caterers may have heat treated the product less thoroughly than an industrial heating process. This situation largely concerned deliveries abroad.
  - It is known that company X has had deficiencies with regard to food and feed safety for quite some time (several years).
  - The finished product of company X has been used (in addition with other flaws in food safety legislation) for the production of raw pet food; although not intended for human consumption, it is known that pet owners can also become infected through unhygienic handling of this raw pet food.
  - In recent years, the NVWA or the RIVM have not received reports of cases of illness that could be linked to products made with raw materials originating from company X. There may have been cases of illness (or they could have occurred abroad), but that these remained under the radar. Note that cases of illness are subject to underreporting (for *Salmonella,* for example, by a factor of 26) and that of many reported cases, the cause of illness is unknown (for example, which food or which other source caused the infection).
  - Furthermore, hardly any reports have been made to the NVWA by customers of company X regarding microbiological deficiencies concerning raw materials manufactured by company X (as far as is known, one report has been received regarding an unsatisfactory test result for *E. coli* in minced meat). However, reports have been made by customers to company X regarding the microbiological quality of raw materials, and batches were returned that did not meet the customers' criteria and conditions. It is therefore likely that customers therefore investigated whether this had consequences for the safety of the finished

[4] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs
[5] Commodities Act Decree on the Preparation and Treatment of Foodstuffs
[6] Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

products they produced. If that had been the case, that should have been reported to the NVWA. As far as is known, no such reports have been received by the NVWA.

Gross hygienic violations were committed in the production process of minced meat manufactured by company X. This has resulted in finished products from company X that did not comply with applicable process and food safety criteria, resulting in raw materials that are unfit for human consumption and injurious to health. Process and food safety hygiene were compromised to such an extend that fraud was committed regarding the mandatory microbiological monitoring of the finished products (minced meat) of company X.

A raw material (e.g. the minced meat finished product from company X) that is injurious to health does not necessarily result in a food product that is injurious to health, if, for example, the risk is adequately reduced by a heating process. Based on different scenarios (use of (heavily) contaminated raw materials or spoiled raw materials, inadequate refrigerated storage of raw materials and finished products, see Figure 1), the conclusion is that it is likely that an industrial heating process will be sufficient to control the additional risk posed by higher concentrations of pathogens (compared to a hygienic manufacturing process) in the finished products of company X.

It is possible that formation of biogenic amines has occurred in the spoiled raw materials of company X; the formation of mycotoxins seems unlikely. Pasteurisation has no effect on the presence and negative effects of biogenic amines. However, due to the mixing that will have taken place in the manufacturing process, it does not seem likely that the formation of biogenic amines in the raw material resulted in unsafe foodstuffs (injurious to health) and consequently that any additional risk has arisen.

This risk assessment is based primarily on the situation concerning the production of minced meat, where spoiled and contaminated raw materials are masked by diluting and mixing them with raw materials suitable for human consumption. Company X also produced fresh meat (e.g. beef cheeks) from boned beef heads. Contamination and spoilage in this cases are easier to detect sensorially (sight, smell) and are more difficult to mask by mixing. The assumption is that the fresh meat produced by company X will not be microbiologically contaminated to a higher extend than the minced meat. The conclusions for minced meat are therefore also applicable to the fresh meat.

## Uncertainty analysis

This risk assessment concerns minced meat and the fresh meat produced at company X following a criminal investigation by the IOD of the NVWA into fraud in various aspects of food safety legislation. Due to this criminal investigation into fraud, a significant amount of information has been deliberately withheld by company X, and new information is still to be expected. BuRO based this risk assessment on the information known to BuRO on June 5, 2026.

The assessment was carried out using scenarios in which rough estimates have been made. Given the worst-case margins that have been considered, it is likely that this approach has led to a plausible outcome.

## Conclusion

It is likely that batches of minced meat and fresh meat produced by company X can be injurious to health and pose an additional risk compared to a manufacturing process carried out under good hygienic practices. If these batches are used as raw material for the production of heat treated meat products in establishments approved for this purpose (Approved food establishments: Meat products - Processing plant), it is likely that the additional risk – being higher concentrations of pathogenic micro-organisms – that these raw materials may pose is adequately controlled by this heating process.

## Answer to the question

*Is there a risk to microbiological food safety (excluding prions) if the minced meat and fresh meat produced by company X – given the observed violations of food law by company X – is processed in establishments approved for this purpose and which apply a pasteurisation process to these raw materials?*

It is likely that the microbiological risk additionally created by the management of company X is adequately controlled by an industrial pasteurisation process as carried out in approved food establishments (meat products approval). This does not alter the fact that raw materials (animal by-products category 1, 2 and 3) not intended for human consumption have been used, and that company X thereby has placed foodstuffs on the market that are not fit for human consumption.

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# Annex

## List of terms

**Animal by-product (ABP):** 'animal by-products' means entire bodies or parts of animals, products of animal origin or other products obtained from animals, which are not intended for human consumption, including oocytes, embryos and semen; (Regulation (EC) No 1069/2009)

- Category 1 material poses the highest risk and comprises mainly of material considered to be a TSE risk, i.e. specified risk material (SRM).
- Category 2 material includes dead animals, manure and the contents of the gastrointestinal tract. Category 2 is also the default status of any animal by-product not defined as Category 1 or Category 3 material in the ABP Regulation, and includes material such as waste from slaughterhouse disposal.
- Category 3 material is considered low risk and includes parts of animals slaughtered and that were considered fit for human consumption but are not intended for human consumption either because these parts are normally not consumed (skin, hair, feathers, bones) or for commercial reasons. Category 3 material also includes waste of animal origin from the food industry (by-products from food industry and former foodstuffs).